IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 04, Issue 10 (October. 2014), ||V2|| PP 31-38

Cross Shift In A Vehicle With A Manual Gearbox

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Abstract: - The cross shift behaviour of a gearbox in a vehicle will be explained. The elements which are involved will be described. Cross shift in a car under static and dynamic condition will be checked. The results of these tests will be described. The shift track of a six gear transmission in a vehicle is illustrated. All elements where a cross shift stuck can occur will be mentioned. The stuck areas are also described. A solution for this item will be found, where no cross shift stuck can ever happen.

Keywords*: cross shift, shifting behaviour in a car, elements of cross shift, static cross shift, dynamic cross shift*

I. INTRODUCTION

The shifting behaviour of a transmission in a vehicle is one of the most important things during the development phase. In the shifting process many parts are involved. The outer shift mechanism and elements which are not included in the cross shift process will not be mentioned in this paper. Driver needs a good static and dynamic performance of a gearbox. Therefore all possible applications for a transmission have to be checked and analyzed. Only cars with a good working gearbox will be bought. The requirements of a gearbox are increasing. All the tests were done in cooperation with a European car manufacturer. The final product will be build up in a new type of car of this vehicle manufacturer. A lot of investigations in warm and cold conditions were done to fulfil the requirements.

In order to assess the state of development and the development progress of the shift quality objective, it is necessary to have measurable criteria. The shift quality is according to (Gebert, 2000), (Kücükay and Gebert, 1997) and (Kücükay and Renoth, 1995) a subjective judgment of the vehicle occupant. This judgment depends on factors such as the switching frequency, the response time, the course of the vehicle acceleration a(t) and the associated jerk, as well as the acoustic impression during the shift. A shifting can be described and characterized over the course of acceleration and jerk (Naruse, et. al., 1993), (Schwab, 1994).

II. STATIC AND DYNAMIC CROSS SHIFT

Cross shift is the shifting process from second gear into the third gear or from fourth gear into fifth gear for up-shift and the other way for down shift. Not everybody is shifting in the same way. Some people shift in an H schematic and other people shift in an S way. A lot of the driver shift directly between the gears. A transmission must have a good cross shift behaviour, no matter who will shift. Different elements are involved in the cross shift process.

Static cross shift

The graph below shows the forces during shifting from second gear into third gear. A transmission must have a good static behaviour because many people will check the gearbox before buying the car under static conditions. If the showroom behaviour of the transmission is bad, for example gear stuck happens then no driver will buy this car or make a test drive with the intent to buy this vehicle. Cross shift under dynamic condition takes place during driving, when the engine is working.

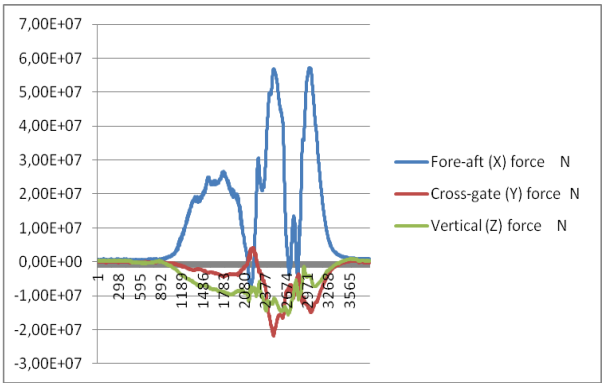

Figure 1: Static cross shift force

In this graph the travels during shifting from second gear into third gear were shown. In this chapter all the travel and forces will be described in x, y and z direction, because then a meaningful statement can be made.

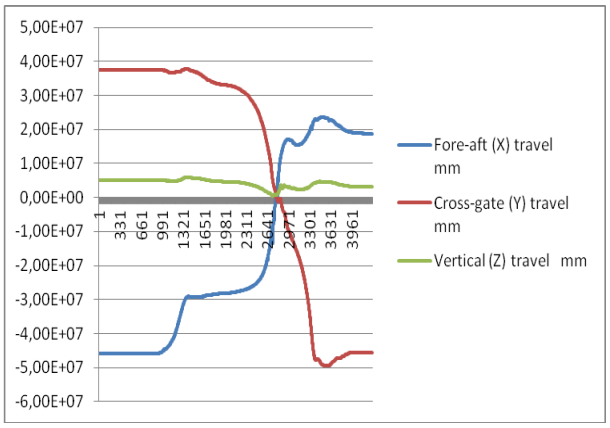

Figure 2: Static cross shift travel

Dynamic cross shift

The graph below describes the shifting behaviour of a transmission during the shifting from second gear into third gear. The force of every direction is shown in a different color. The Cross-gate force under dynamic condition is higher than under static condition. The peak of the Fore-aft force is also higher than under static condition, but the general force behaviour in this direction is lower. Only the Vertical force process is similar under static and dynamic conditions.

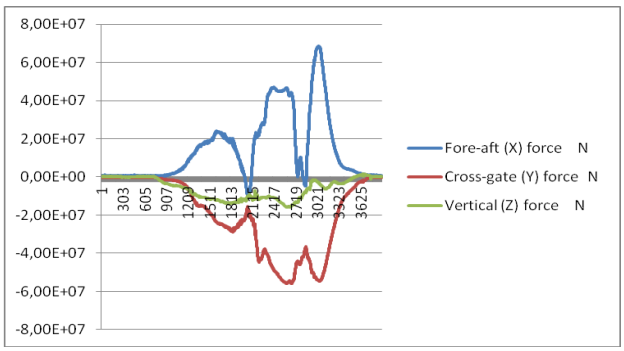

Figure 3: Dynamic cross shift force

In this graph the travels from second gear into third gear shift is mentioned. The travel of every direction is shown in another color. The cross gate travel has under dynamic conditions a big neutral area, but under static condition the neutral area is very small.

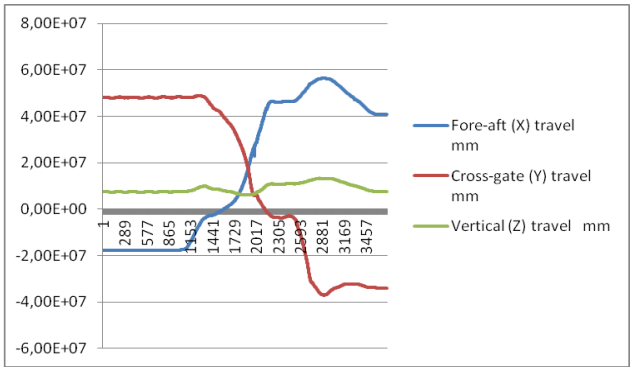

Figure 4: Dynamic cross shift travel

Dynamic shift behaviour of a transmission is very important for evaluating a vehicle concerning its shift ability. It is allowed to have sometimes gear stuck, but the likelihood has to be less than 1%. First gear stuck will never be accepted.

III. CROSS SHIFT ELEMENTS

In this chapter there will be mentioned the elements and how they have to look like for a good cross shift behaviour. It can be optimized on the elements of the shift tower and head of the gears like shown in the graphs below. Additional element for a good cross shift is for that purpose a proper gate plate.

Shift tower

The shift direction is horizontal and the select direction is vertical in the graph below. These two directions are indicated with the blue arrows in the graph below. The shift tower is from a 6 gear manual transmission. The gears in the graph from down to up will be mentioned in the following sentences. The head of the reverse gear is the two squares with the rounded edges. Above of the reverse gear there is on the left hand side the head of the fifth gear and on the right hand side the head of the sixth gear. Then above there comes on the left hand side the head of first gear and on the right hand side the head of the second gear. On the top under the blue arrow there is on the left hand side the head of the third gear and on the right hand side the head of the fourth gear. The interlock plate is the element where the blue arrow shows the select direction. The element above and below the inter lock plate is the inner lever of the shift tower. Stuck in cross shift can happen if the interlock plate is not optimized, because then double engagement is possible or if the shift force and select force is equal. In that case a stuck between the gear head and the interlock plate can happen.

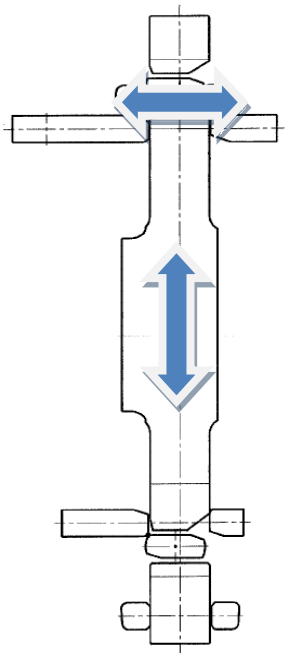

Figure 5: Shift tower

Gate plate

The graph below shows the gate plate on the right hand side and the guide pin on the left hand side. The guide pin can only move in the gate plate given ways. The gate plate can reduce the selecting free play and has an influence in the shifting behavior as it is explained in the chapter Gate track. In the right graph the middle area from top to down between the tips of teeth is the selecting area and between the teeth on the left and right hand side there is the shifting area. The gate plate is fixed on the shift tower and the guide pin is fixed on the transmission housing.

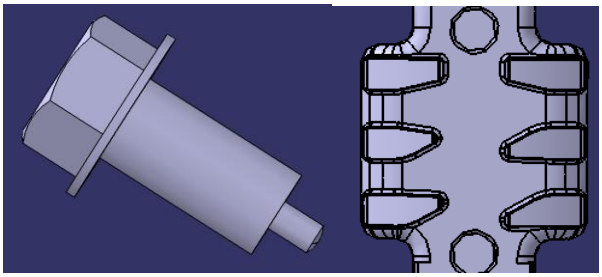

Figure 6: Gate plate and guide pin

Shift track

In a shift track there can be seen the areas where it is possible to shift in a vehicle. The graph below shows two shift tracks which are not good. It is easy to get stuck if you shift from second to third gear, this can be seen in the middle of the way from first to third gear where the sharp bend is existing shown in the circle. The blue track is worse than the red one but both are not good. A similar problem exists between the fourth and fifth gear. Both tracks are akin and stuck happens very often. It is also seen that it is easy if you want to shift from fourth to fifth gear that you come into the third gear. This problem comes from the u-form of the track. All the sharp bends in the tracks are not good for the shifting behaviour.

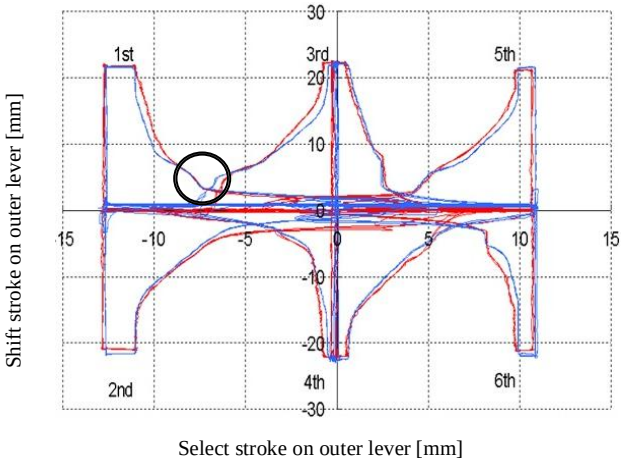

Figure 7: Shift track

Stuck surface

The green line in the graph below shows the stuck surface. The select direction is from down to up. The shift selection is from the right hand side to left hand side. If the edge and the stuck surface get in contact then it is not possible to engage the gear, this scenario is shown in the graph below. If a transmission is built up in this way then stuck often happens. The areas with the arrows belong to the shift tower and the stuck surface belongs to the head of a gear.

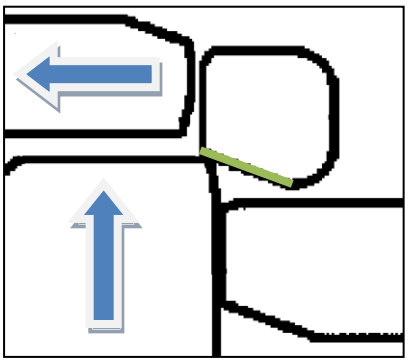

Figure 8: Stuck surface

Gate track

The idea behind this optimization is to make the head of the gear sharper and to reduce in that way the shift stuck area. The graph below shows different kind of sharpness of the head of the gears. This is shown in the full black lines. It is not allowed to make it to sharp because then the durability test will not be passed anymore and the travel to engage a gear will get very big. This effect is also not good for the shifting behaviour in a vehicle. Too many stuck in a vehicle will not be accepted by the costumer and also the complete shifting behaviour in a vehicle has to fulfil the requirements of the costumer. The slashed lines in the back describe the gate plate area. To avoid stuck a good combination of slashed line and full black line has to be found. If the full black line is wider than the slashed line than stuck could happen at the intersections of this two lines. Therefore the gate plate should be in a way that it will not disturb the shifting behaviour. The gate plate should help to get a good shifting system in the vehicle.

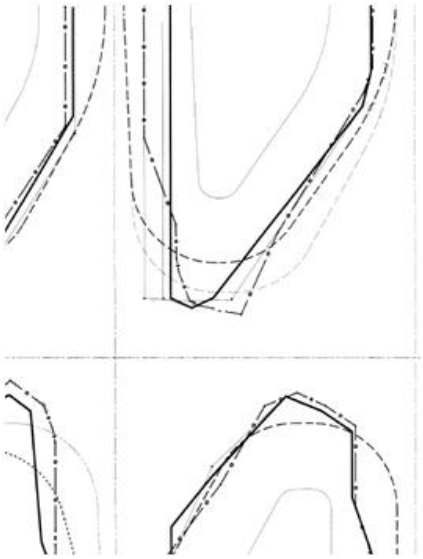

Figure 9: Gate track

IV. OPTIMIZATION ON THE SHIFTING TOWER

Two ways for cross shift stuck are possible. The first possibility is at the gate plate and the second one is at the interlock plate. The graph below shows the gate track with the guide pin. The interlock area with the head of the gear is smaller than the area of the gate plate. Therefore a stuck due to the gate plate area is not possible anymore. If a stuck in a vehicle happens with a gate track like shown in the graph below then it is because the chamfers between the interlock plate and the head of the gears are not optimized. The interlock plate is to avoid that two gears can be engaged at the same time and so the interlock plate must look in a way that it should not have an influence in the cross shift behaviour. The guide pin can move between the gears because the distance between the area at the top and at the bottom is big enough. The areas between the top elements and the areas between the bottom elements are also width enough for an easy engagement of the gears in a vehicle. These distances have an influence in the select vibration and so it should not be too big for a perfect shifting.

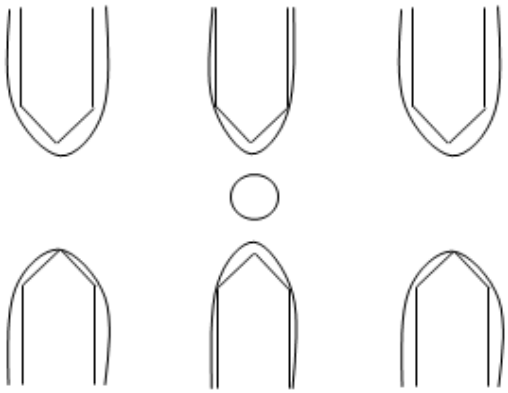

Figure 10: Optimized gate track

Stuck area

The stuck areas are marked green in the graph below. The stuck areas are limited by the tangents of the gate plate and the angles of the teeth. In this example below there are only two stuck areas mentioned, but in the car there would be 12 stuck areas. Six stuck areas would go from top to down and six areas would go from down to top. In this example no stuck in a vehicle could happen because the areas don´t cross the teeth of the gears and no intersection points between gate plate and teeth exist. So the gears will always be engaged on the gate track side.

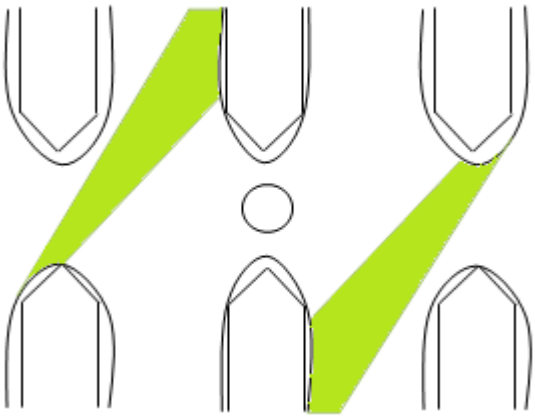

Figure 11: Stuck area

Interlock function

The second possibility for a cross shift stuck and how to solve it is mentioned in this chapter. The interlock function has to be opened early when a cross shift is done. The graph below shows a shifting tower and the green marked area shows the radius from the interlock plate. If it is necessary to change the chamfer length then this can be done by rounded shape of the interlock plate. It was found out that the lack of interlock will cause cross shift lock, so it is proven that the round shape of the inter lock plate has an effect on cross shift performance.

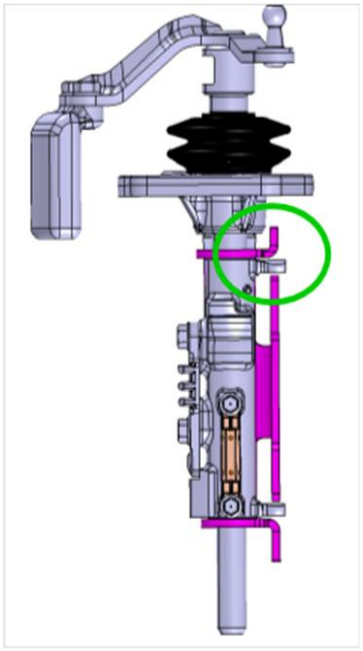

Figure 12: Shifting tower

The graph below shows the interlock plate and the teeth of four different gears which are involved in a cross shift process in a vehicle. In that case the teeth of the first four gears are shown, so a cross shift from 3 to 2 is possible, which is shown by the blue arrow.

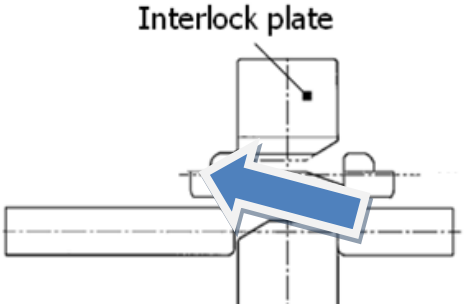

Figure 13: Interlock plate

The graph below shows the situation when the bending portion has to be changed in order to keep enough chamfer length. This can be seen at the green element.

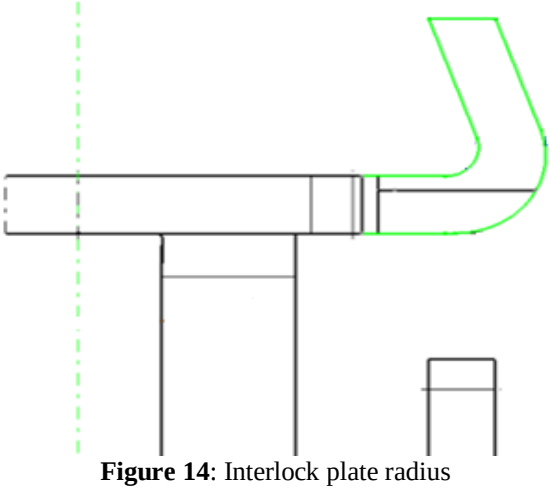

Figure 14: Interlock plate radius

The graph below shows the interference of the interlock plate shape change. The green areas with numbers show that there is an enough clearance between the elements.

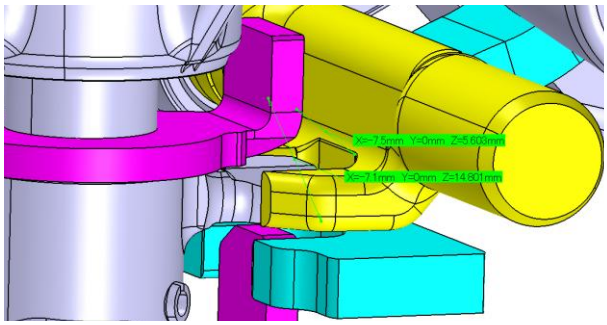

Figure 15: Interlock plate surrounding check

V. CONCLUSION

Cross shift and all elements which are involved in this process are explained. Tests in static and dynamic conditions were done with different transmissions and different cars and also measurements on the workbench were done. Results of these tests were described. A shift track for a six gear transmission was shown. All elements were stuck of a gear can happen were described. Also the stuck areas were mentioned. The two ways of cross shift stuck are described. An optimum solution for this item was found, where no cross shift stuck can ever happen.

REFERENCES

[1] Gebert, J., 2000. Adaptive Parametervariation bei Getriebesteuerungen zur Optimierung des Schaltkomforts. Düsseldorf: Fortschritt- Berichte VDI, Reihe 12, Nr. 424, VDI-Verlag.

[2] Kücükay, F. and Gebert, J., 1997. Schaltkomfort als neue Regelgröße bei PKW-Automatikgetrieben. Berlin: Tagesband, Symposium: Steuerungssysteme für den Antriebsstrang von Kraftfahrzeugen, 18./19.9.1997

[3] Kücükay, F. and Renoth, F., 1995. Intelligente Steuerung von Automatikgetrieben zur Optimierung von Komfort, Verbrauch und Fahrbarkeit. VDI Berichte, Nr. 1175

[4] Naruse, T., Nakashima Y., Murayama, Y., Akiyoshi, Y. and Kurachi, T., 1993. A Study on Evaluation Method and Improvement of Shift Quality of Automatic Transmission. SAE 930673

[5] Schwab, L., F., 1994. Development of a Shift Quality Metric for an Automatic Transmission. SAE 941009