Freight wheel profile selection for Iran rail Network

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***Abstract*—Wheel profile and it's geometry has a significant effect on wheel-rail life span, safety, wagon vibration, track forces and noise. An optimum selection for a wheel profile is a factor of track and fleet characteristics. In this study with respect to reducing wear, Iran rail network and freight cars defects are studied statistically. In the next step, based on rolling radius difference (RRD) diagram, candidates for wheel profile are chosen amongst standard ones. The final solution stands until finishing field test.**

***Keywords*—Iran rail network, open wagon, Wheel profile, wear, RRD diagram**

I. INTRODUCTION (*HEADING 1*)

By implementing economical aspects into railway operation, maintenance and repair became bold. In general, defects in a wheel-rail system can be categorized into wear and RCF. Wear is defined as mechanical loss in contact surfaces of bodies under loading. This process is slow and can be controlled [1]. At first wear and its expenses were considered only as annual costs. By increasing speed and axle load, a noticeable increase occurred in wear of elements and consequently their maintenance costs. As a result this phenomenon was considered and studied by researchers in details. Wear is caused by improper wheel-rail interaction. Wear can also decrease rolling stock efficiency and can also increase fuel and lubricant consumption [2].

Pearce and Sheratt in 1991 presented a simple model for wear calculation. They considered a S-track followed by a tangent one. After calculation contact forces and creepages, removed mass volume was estimated by employing wear index [3]. Grassie and Kalousek in 1993 concluded that longitudinal slips are the main cause for wear in a track with short-pitch irregularity. They also considered that wear is occurred only in severe mode and it is related with friction power [4]. Zobory considered two wear regime in his analysis: mild in tread and severe in flange. Change between regimes was done by defining a jumping factor. He also calculated both wear of wheels and rails [5].

Many researchers consider wear only in wheels and rail profiles remain constant . Zakharov in 2002 with the help of roller testing investigated simultaneous wear of wheel and rail [6]. Jendel in 2002 modeled mutual wear of wheel-rail system. As a result of his works, different methods for wear estimation are developed [7]. In 2008 Xie and Iwnicki developed a 3D model for calculating railhead wear with the presence of short-pitch irregularity. They also used a non-Hertzian and transient contact, based on Kalker's method [4,8].

II. IRAN RAIL NETWORK

Iran has 8072 Km standard railroad consists of 84% tangent and 16% curves. Fig. 1 shows a sum of tracks for each curve radius. The distribution of right and leftward for each curve radius is almost the same. As it can be seen from Fig. 1, curve radiuses can be fall into 3 groups: less than 600 m, between 600 and 1200 m and larger than 1200 m.

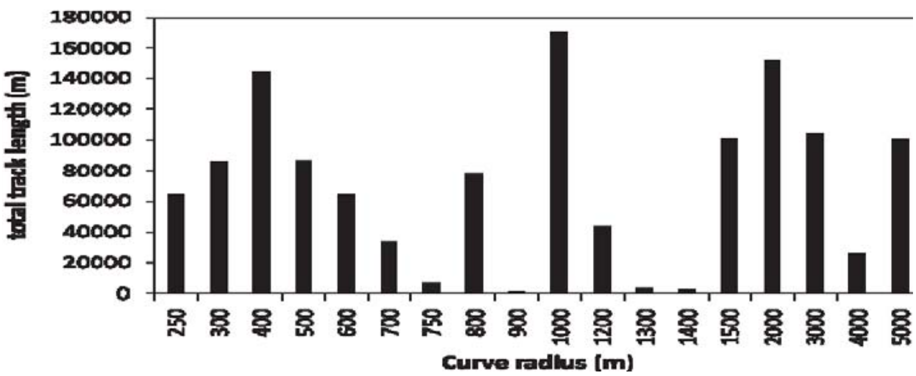

Fig. 1. Distribution of curve radius for Iran rail network

By unifying curve radius length into three mentioned categories, it can be concluded that curves with the radius less than 600 m consist 35%, between 600 up to 1200 m are 26% and the rest 39% are for the curves with radius larger than 1200 m (Fig. 2).

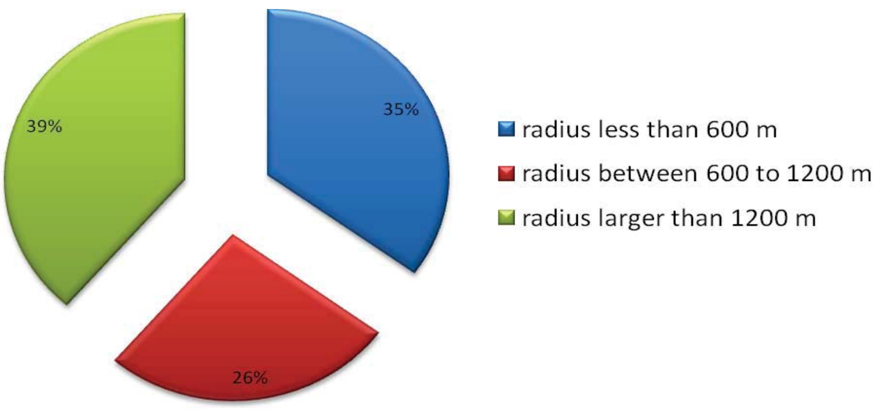

Fig. 2. Ratio of total curve length for each category

Different wheelset defects and related ones such as axle box and suspension system for open wagon was investigated in a period of 3 years (2011-2013) [9]. Fig. 3 shows wheelset defects for two common commercial bogies. Russian 18100 bogie shows more ratios of defects compared to H665. H665 bogie shows a constant trend while Russian 18100 defects decreases. The vertical ordinate is the ratio of defects number to wagon number for each bogie type.

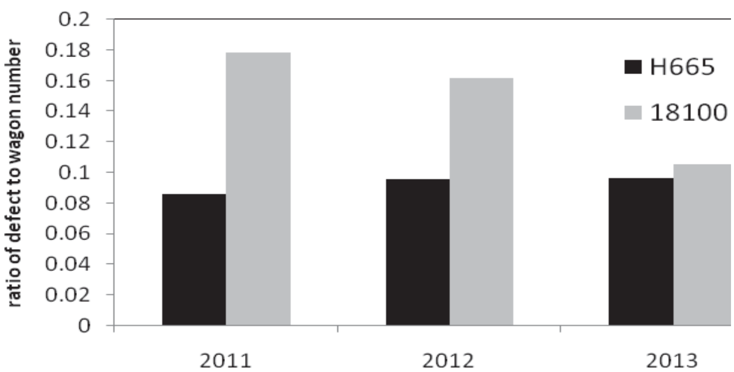

Fig. 3. Wheelset defects for open wagon equipped with H665 and Russian 18100 bogies

In the next step with respect to constant trends of defects, a survey study of wheel defects in details was done. Fig. 4 shows the results for a period of 14 months. Amongst 5612 wheelset defects, 37% of defects are related to flange thickness, over length, etc. 2% are related to hollow worn and grooved tread, 9% are local defects on tread like wheel flat, spalling, RCF, etc. the other 52% belongs to axle defects, wheel rim misplace or minor ones like broken thread.

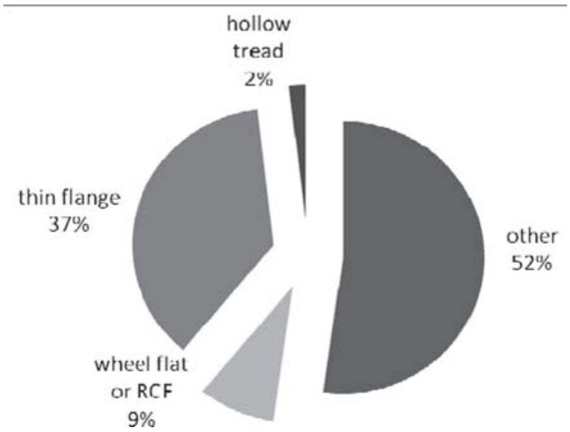

Fig. 4. Distribution of wheelset defect in Iran freight railway

III. Geometric Analyses of the Alternative Wheel Profiles

There have been considerable efforts on reducing the standard wheel profiles in a rail network. This condition is preferred mainly as a result of track-rolling stock maintenances in addition to technical and economic advantages. In order to reach to an appropriate wheel profile suitable for the interested rail network, a survey was done to the already wheel profile design methods developed. The preliminary factors in selecting such method were the costs and dependency to wheelset RRD (improvement in wear behavior and curving performance). Therefore a method which was developed by Esveld and colleagues [10] with respect to EN13715 standard [11] was used. Thus new and worn wheel profiles in addition to rail inclination were required for wheel wear pattern and stable determination. Thus the selected wheel profile RRD must lie between new and worn wheel profile.

The more selected wheel profile is close to stable worn profile, the better will be the wheel profile performance. Investigations were focused on the study of the standard wheel profile RRD with rail inclination of 1:20. The idea was to find the standard wheel profile which contain RRD close to stable worn wheel profile and represent acceptable wear behavior. It is to note that in studies, other wheel profile features such as lateral stability and resistance against RCF was not considered. The main reason is that there is no possibility of designing a wheel profile which shows good behavior in aspect of wear, RCF, stability, curving and etc (some of these features are against each other). Moreover the current main issues in Iran track network is excessive wheel and rail wear.

Thus the selected wheel profile and rail are deserved to have continuous contact distribution point, not considerable contact point jump and proper curving performance. The lateral stability feature of the selected wheelset was not a crucial matter since the freight rolling stock running speed is not noticeable.

Wheelset RRD and equivalent conicity diagrams for various candidate wheel profiles gained from Universal Mechanism (UM) software are shown in Fig. 5 and Fig.6.

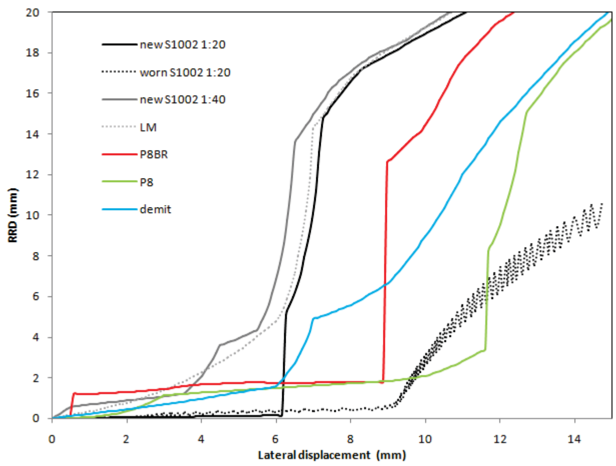

Fig. 5. Wheelset RRD function for various wheel profiles in contact with UIC60 rail profile with 1:20 rail inclination

On the selection of the appropriate wheel profile with mentioned features and operational conditions (UIC60 rail profile, track gauge 1435 mm and 1:20 rail inclination), wheel profiles which are in use in countries such as China, UK and Russia were in preference. Despite the Russian track gauge 1610 mm, as a result of rail inclination 1:20 and their success in developing appropriate wheel profile for freight rolling stock (especially three piece bogies); their standard wheel profile was selected for further studies.

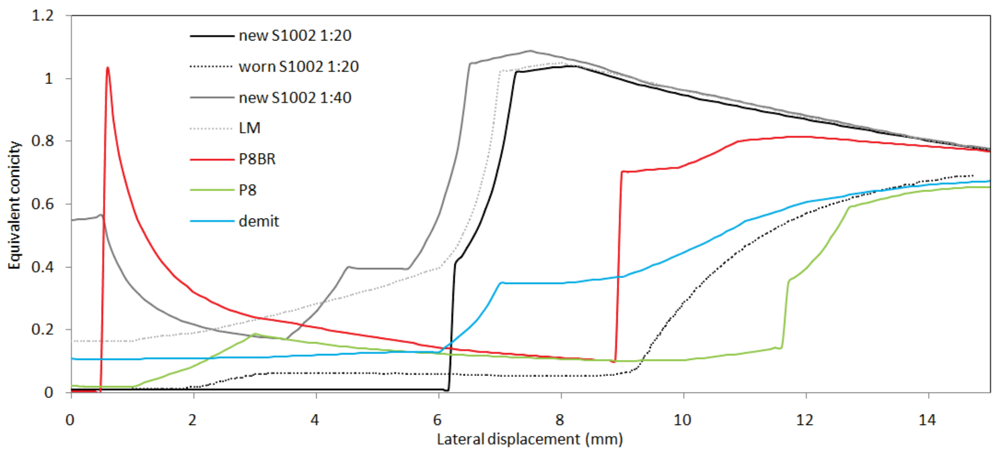

Fig. 6. Wheelset equivalent conicity for various wheel profiles in contact with UIC 60 rail profile and 1:20 rail inclination

Standard Chinese LM wheel profile, Russian DMETI wheel profile and British P8 (BRP8) wheel profiles were selected for thorough investigations. The studies by MMU University showed that the BRP8 wheel profile shows good dynamic performance [12].

The Chinese LM wheel profile has a flange thickness similar to S1002 wheel profile which decreases the safety issues especially in switch and crossings. It also has a behavior pretty similar to S1002 wheel profile with 1:40 rail inclination. Fig.7 shows various wheel profile contact point distribution on UIC60 rail profile with 1:20 rail inclination.

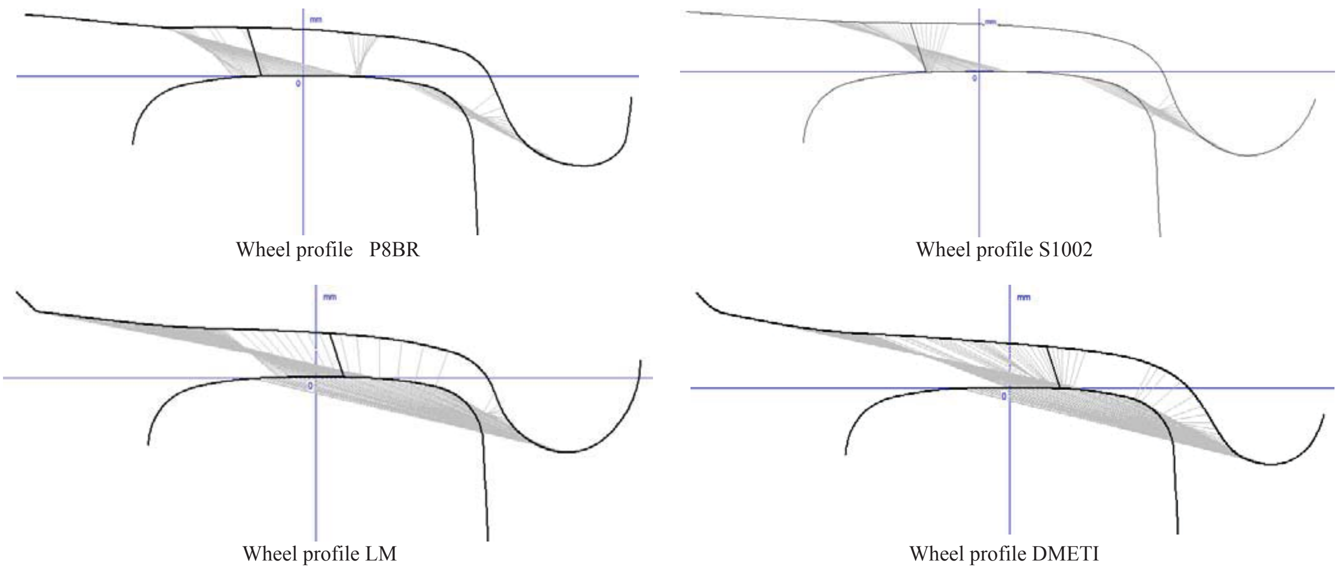

Fig. 7. Wheel-rail contact point distribution for various wheel profiles with UIC60 rail profiles and 1:20 rail inclination

As it is seen from geometric investigations that the LM and DMETI wheel profiles have more suitable wheel-rail contact point distribution from the aspect of sudden change in wheel rolling radius and rail-wheel flange clearances.

Further investigations are required to be done to fully study the nonlinear effect of wheel profile and wheel-rail contact point distribution on the curving performance and wheel wear pattern which are mainly transient and stable worn profiles behavior. More thorough studies on wheel wear rate at wheel tread and wheel flange in addition to wheel profile variation will be performed by simulations and then field test investigation.

IV. Conclusions

In this research the investigations were devoted to the selection of the appropriate wheel profile based on the method developed by Esveld. The main idea was to improve wheel wear behavior in Iran freight rolling stock. Thus various standard wheel profiles were compared with respect to geometric parameters such as Wheelset RRD function and wheel equivalent conicity. Some appropriate wheel profiles were selected for further investigation to fully study their dynamic performance especially wear and curving behavior by simulations and field tests.

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